DEVELOPMENT OF INCREMENTAL FORMING MACHINE

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Bachelor of Mechanical Engineering with Manufacturing

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This research was carried out to develop and analysis an incremental forming machine controlled by personal computer; numerical control (PC_NC). The application of this machine is to realize a small production lot with low cost. The process which runs without mould can be used to replace stamping applications which is very costly due to the mould application. Aim of this study is to analysis in contour geometry of forming relation to the tool path and relate with speed, torque and time of forming process. The analyses show the implication and justification for forming process. The experiments result determine the justification and FEM have been achieved with the purpose to compare between experimental and simulation. Experimental process and analysis have been use to determine the tool path in the design phase for continuous operation.

ABSTRAK

Kajian ini merupakan hasil pembangunan dan analisis mengenai mesin pembentukan berterusan yang dikawal oleh sistem kawalan berangka menggunakan komputer peribadi (PC_NC). Aplikasi mesin ini adalah untuk mencapai jumlah pengeluaran yang kecil dengan kos yang rendah. Proses yang dijalankan tanpa menggunakan acuan ini boleh menggantikan aplikasi mesin penekan yang menggunakan acuan yang mana kosnya lebih tinggi. Matlamat penyelidikan dalam analisis ini adalah berkenaan garis bentuk mata alat dan berkait dengan kelajuan, tork dan masa dalam proses pembentukan. Analisis menunjukkan implikasi dan justifikasi terhadap proses pembentukan ini. Eksperimen menunjukkan justifikasi dan FEM digunakan dengan tujuan untuk membezakan antara eksperimen dan simulasi. Proses eksperimen dan hasil analisis ini digunakan untuk memastikan garis bentuk mata alat dalam fasa merekabentuk untuk operasi yang berterusan.

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LIST OF SYMBOLS

P	Applied Load
F	Force
T	Torque
t	Thickness
r	Radius
G	Shear Modulus
k_s	Shear Coefficient
σ_{max}	Local maximum stress
S_f	Fatigue strength

LIST OF ABBREVIATIONS

AC	Alternating current
CAD	Computer-aided drafting
CAE	Computer-aided engineering
CNC	Computer numerical control
DC	Direct current
FLD	Forming limit diagram
FEA	Finite element analysis
L	Reactor
MC	Magnetic contactor
NF	Noise filter
NFB	Circuit breaker
PC_NC	Personal computer-numerical control
SOP	Standard of procedure

CHAPTER 1

INTRODUCTION

1.1 Background of Project

Incremental forming processes have been introduced in the recent past as an alternative to the money consuming stamping technology when small batches have to be manufactured. Incremental forming is a new technology and not fully assessed process. The continuous improvements of this machine have been development and help to improve the application of this machine.

In Universiti Malaysia Pahang (UMP), the researchers from mechanical department have done this research for design, analysis and development in incremental forming machine. The overall process was controlled by utilizing personal computer; numerical control (PC_NC), the new control process for numerical control with cheaper cost. This manufacturing project started with duration one year; start in April 2007 until March 2008. This research produced a new concept of forming process which is cheaper, efficient and suitable for SMI/SME industry, which will benefit the manufacturing industry in our country.

Three axis mechanisms were applied to this incremental forming machine by applying automatic control system. A lot of applications are using this mechanism and make the engineering process easier and efficiencies. The introduction of three axis mechanism machine has changed the manufacturing industry by increasing the automation of manufacturing process which the improvements in consistency and quality has been achieved.

1.2 Objectives of Project

a) Analysis in contour geometry with different depth and tool path.
b) Analyse and optimise the parameters and characteristics of incremental forming process

1.3 Scopes of Project

The scopes of the project are cover from:

a) Fabricate the system control for incremental forming machine with C language programming.
b) Conducted three different experiments:
    - Different depth analysis
    - Tool path strategy analysis
    - Incremental depth analysis and comparison with Finite Element Analysis (FEA)

1.4 Problem Statement

There are many kind of sheet forming such as stamping, punching, deep drawing, bending, stretching and so on. Incremental sheet forming is one of the processes to form the sheet metal. This machine has well assembled but not has a standard procedure for other people. These research need to show the implication of incremental forming.

Implementation of the technological process of incremental forming is intended for rationalization of small batch production. Using it, the time necessary for prototype making can be shortened. For this purpose a number of forming processes are commonly know such as mechanical striking, impressing, water jet and a more recently developed guiding of the forming tool on forming machine tool along the sheet metal until the desired shape is reached.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In a modernization country, there were so many technologies being develop one and another. Day by day almost all of those technology and inventions being improved for a better performance since there were some problems occurred during their services. Therefore in product development there was an obviously increasing in product designing and producing a new technology in industry.

For designing in engineering field, there were a widely used of part made of sheet metal. In sheet metal forming technique in manufacturing parts such as deep drawing, dedicated tools are needed and this type of forming are highly specialised, expensive and time consuming in production parts. Therefore there is a new sheet metal forming techniques being introduced, incremental forming ring test, being introduced.

2.2 Historical Perspective

A new incremental forming machine has been built in Cambridge and was commissioned in October 2004. The basic for the machine design is described, including estimates of tool forces, the need for access to the reverse side of the workpiece and the need to cope with high horizontal loads at the tool tip. The tool-mounting has been design to rotate freely but passively and to allow for simple exchange of tool tips. The workpiece is mounted on a set of load cells providing a six

degree of freedom constraint without moment loading of the cells. The initial operation of the machine is briefly described [1].

Interest in Incremental Forming began with work in Cambridge by Powell and Andrew in the early 1990's was taken up in Japan principally by Matsubara and Kitazawa and has in the past five years gained increasing interest world-wide. The Amino Company of Japan have developed a specialist machine for incremental forming which is used by the group of Hirt in the University of Saarland. All other research published on incremental forming has been developed using convectional CNC machine tools with specially designed non-cutting tools and appropriate workpiece mounting. This is the approach that has been taken by the groups of Jeswiet, Duflou, Micari, Yang and Bramley.

2.3 Concepts of Incremental Forming

The lack of access to the reverse side of the workpiece is significant for two reasons. Firstly, modelling of incremental forming is complex and solution times for complete simulations of a forming operation are currently many times greater than the times required to form the product. Over the next 10-15 years it is unlikely that simulations will be sufficiently fast to allow inverse modelling for tool path design. The second reason for wanting access to the reverse side of the workpiece is that all existing incremental forming use a single tool operating on one side of the workpiece. Only monotonic shapes may be produced and in controlling the system a tool path must be designed such that all incremental deformations deflect the sheet in the same direction. This restricts the applicability of the process [1].

To achieve higher quality product, a model can be put under the sheet metal as a supporting tool on the basic of which more demanding shapes can be reached. This means more work but it is not time-consuming and expensive because the model can be made on the same CNC milling machine tool with low surface roughness required. The forming condition becomes much worse if, instead of aluminium sheet, steel sheet metal is used for the product. In the case when steel

sheet metal has to be used it is recommendable that this is highly deformable and subjected at minimum hardening with respect to previous deformation.

2.4 Method of Incremental Forming

Sheet metal forming refers to various processes used to convert sheet metal into different shapes for a large variety of finished parts such as aluminium cans and automobile body panels and one of the sheet metal forming is the incremental sheet forming technique where a sheet is formed into the final workpiece by a series of small incremental deformations. High accuracy forming will only be achieved either by repeated trials of tool paths with correction based on errors in the finished form or by use of some form of on-line shape measurement and feedback control with algorithm tool path. Such feedback depends on the availability of an on-line sensor for the instantaneous shape of the workpiece. The movement of the tool starting in the centre of sheet metal and then restarting from the initial depth from the interior in exterior has a priority.

2.5 Wiring of Position Control Model

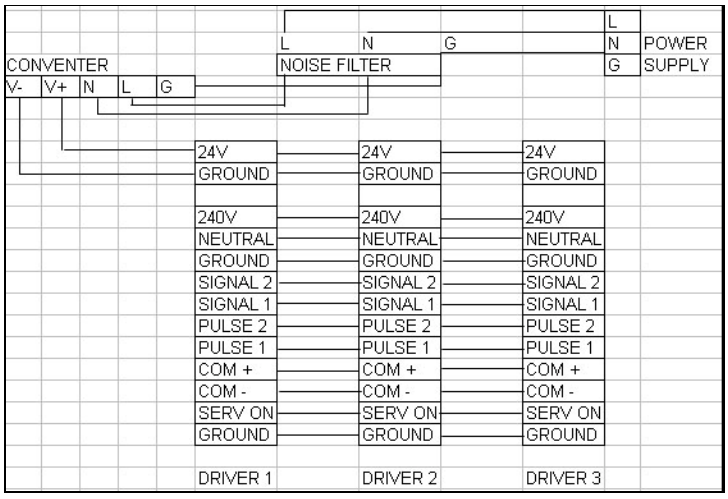

Figure 2.1 Wiring of Incremental Forming circuit

There have three drivers for incremental forming machine and function to run an AC servomotor. The servomotors were combined to generated three axis of this

machine. The axes are x-axis, y-axis and z-axis. The power of main switch was generated from 240 V DC to 24 V AC. Noise filter was use to change the power for suitable power for this machine. From converter, it joined to computer parallel port and the drivers. Te signal of this program were convert to generate by C programmer language.

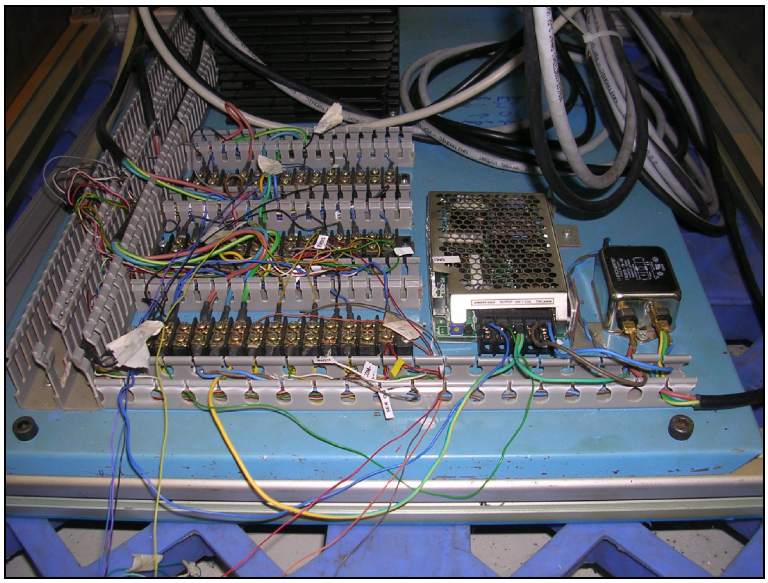

Figure 2.2 The Circuit at the Incremental Forming Machine

2.5.1 Wiring of the Main Circuit

a) Circuit Breaker (NFB)

The circuit breaker matching capacity of the power source to protect the power lines was used.

b) Noise Filter (NF)

Prevents external noise from the power lines and reduces an effect of the noise generated by the server motor.

c) Magnetic Contactor (MC)

Turns on/off the main power of the server motor driver. Use a surge absorber together with this. Never start nor stop the server motor with this MC.

d) Reactor (L)

Reduce harmonic current of the main power.

2.5.2 Introduction of The Motor

Direct current (DC) and alternating current (AC) motors are the two main types of electric motor. Both of motors can be differentia by analyzing the how the electrical current is transferred through and from the motor. Both types of motors have different functions and uses.

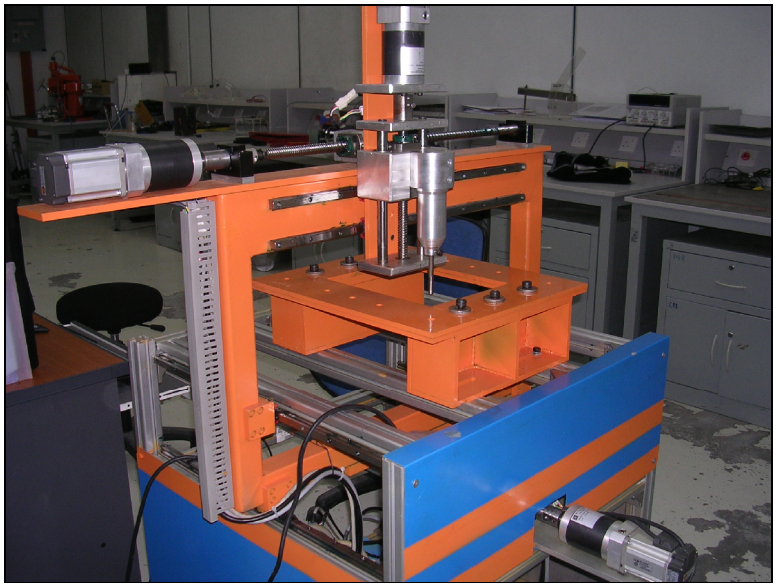

Figure 2.3 Panasonic AC Servo Motor for 3-axis machine.

Table 2.1: Comparison advantage and disadvantage between AC and DC Motor

	AC Motor	DC motor
Advantages	- Maintain torque while changing their speed. - Wide availability of AC power. - Less cost - Eliminates the problem of sparking. - Have good performance in constant-speed application due to its speed is determined by the frequency of the AC voltage applied to the motor terminals. - Simple Design - Reliable Operation - Easily found replacements - Variety of Mounting Styles	- Speed and torque can be controlled easily. - Have a stable and continuous current. - Momentarily deliver three or more times their rated torque. In addition, DC motors can supply over five times rated torque without stalling in emergency situation. - Respond quickly to changes in control signals due to the dc motor's high ratio of torque to inertia. - Easy to understand design - Simple, cheap design
Disadvantages	- Expensive speed control - Poor positioning control - Inability to operate at low speed	- Expensive to produce - Can't reliably control at lowest speeds - Physically larger - High maintenance - Dust

2.5.3 Introduction to the PANATERM Software

PANATERM is using to measure the AC servomotor for command speed, torque and position error. This is a startup the software:

a) Turn on the power to the personal computer to start Windows.
b) Turn on the power to the amplifier.
c) Click “Start” of Windows. (For “Start”, see the manual for Windows)
d) Select “PANATERM” from the “Program” menu, and click it.
e) The opening splash will appear. The opening splash will be displayed for 2 seconds, and automatically change to the PANATERM screen.

After PANATERM is started, a dialog will appear to determine whether to communicate with the amplifier. Also when “File” and “Communication with the amplifier” are selected in the parent window of PANATERM, or when “Communication with the amplifier” on the window menu is clicked, the dialog will be displayed.

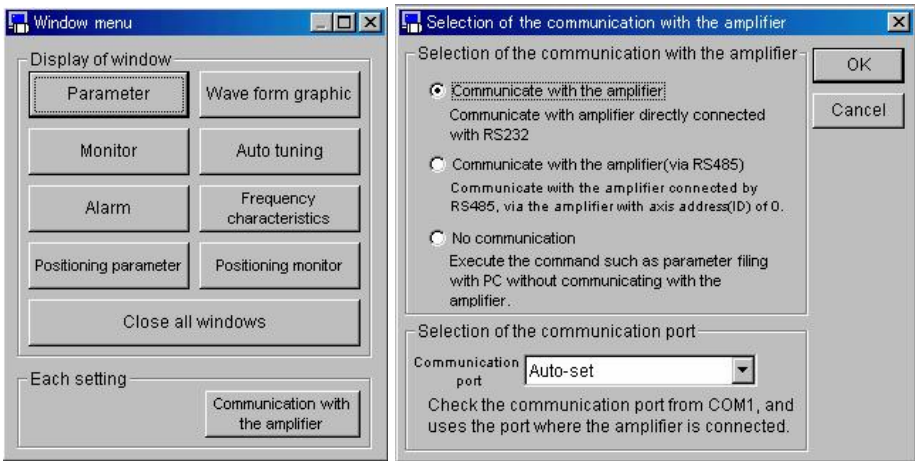

Figure 2.4 Procedure to operated the PANATERM

2.6 Parallel Port Programming

The main objective of this research is to control the machine with PC Parallel port using C programming language. The PC parallel port connector have a 25 pins, the 25-pins represents four main function:

a) First Output Port – the pins from Pin 2 to Pin 9. It is called data register. The voltage controlled by these eight pins through C program. The memory address for this is 888.
b) Input Port – the pins are Pin 10, Pin 11, Pin12, Pin 13 and Pin 15. It is called status register. One of this pin will be connected to switch as input device. The memory address for this port is 889.
c) Second Output Port – Pin 1, Pin 14, Pin 16 and Pin 17. These pins are also output port and are called control register. This is an extra port in case controlling through first port is not sufficient. The memory address for this port is 890.
d) Ground pins – which are Pin 18 to Pin 25. These are PC ground.

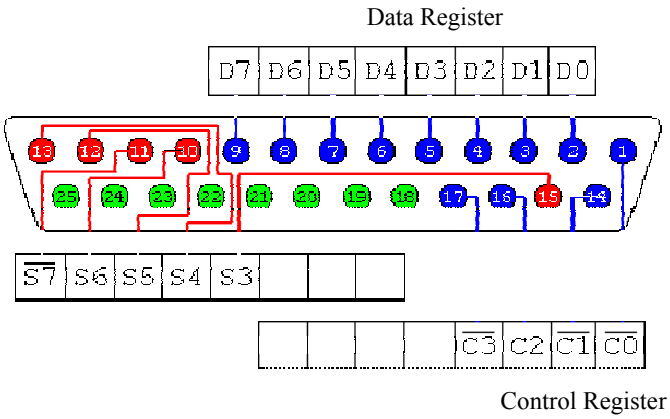

Figure 2.5 Parallel Port Pins

In this research, we are going to use the first output port which is the port with the memory address 888. Seven pins only use for these programming. Pin 1 for output and Pin 2 to Pin 7 for data register. The three drivers (x-axis, y-axis and z-axis) connected with the PC to generate from notepad data to machine programme.